Economic Growth and Human Capital Accumulation: Some Evidence on the Duality Hypothesis

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Ⅰ. Introduction; Technological Progress and Productivity Growth

The Korean economy, especially during last two decades, is characterized by the remarkable economic growth and rapid technical progress. The growth of wages in labor market thus has been considerably influenced by productivity growth due to the technical changes in industries.

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Rapid economic growth process has been accompanied by the wide expansion of public education. Recent studies (Y. Kim, 1980; K. Kim, 1983) have noticed the significant contribution of rapid provision of education to the economic growth in Korea. Workers in the labor market have been provided with more general human capital accumulated from expansion of public education. And such workers equipped with more general human capital could increase their productivity on the job.

Introduction of new technologies would require more complementary worker skills on the job, besides more basic formal education, which are useful for adepting new technologies. Moreover, technology is not a public good, especially in the stage of unbalanced rapid industrialization. Thus there is considerable variation among firms in the technologies they create and adopt, particularly in industries where technology is advancing rapidly. The emphasis on new skill formation derived from the introduction of new technology would involve strong elements of specificity of the on-the-job training.[1]

If the skills emboding new technology are not available outside the firm, then the skill formations on the job due to new technologies would be more firm-specific one, which leads to a higher degree of firm-specificity of OJT. An increase of the amount of OJT would result in steeper wage growth in the firm and lower turnover rates. This phenomenon may be attributed to, at least partially, the differential rates of productivity growth across industries.

Recently there have been various attempts to link human capital theory to the literature on technological progress and productivity growth. Lillard and Tan (1986) showed that demand for education and training is greater in sectors in which productivity grows faster. Their study confirms the empirical finding of the long-term growth of human capital in growing economies. The productivity growth has positive effect on the profitability of (returns to) education and training. They show that positive coefficients of interaction of productivity growth indexes with educational attainment (Pr * Ed) or with training (Pr * Tr) in the wage equations. Mincer & Higuchi (1987) analyze the wage growth when productivity growth is differential across industries. Also, they test the duality hypothesis derived from specific human capital theory. Bartel & Lichtenberg (1985, 1988) also found that industries with a high rate of technical change pay higher wages to workers of given age and education. Becker & Murphy (1988) exhibit a model in which human capital grows relative to physical capital as an economy develops. An empirical study by Gill (1988) also suggests that sectors expecting relatively rapid changes in technology are shown to employ a greater proportion of more educated workers, and his examination of experience-earnings profiles for each schooling level verifies that education is complemntary with technical progress.

The fact that the relatively high rates of return to education have been maintained in Korea as well as in Japan despite the rapid growth educated labor supplies is consistent with the increases in demand for educated labor force due to the higher rates of technological changes.

Our issue here is to investigate the effect of technological improvements on the decision of individual workers and firms regarding the investments on the job training.

Ⅱ. Growth of Wages with Key Human Capital Variables; Some Comparison With U. S. and Japanese Results

The wage equation which is to be estimated is of the usual human capital earnings function:

$$\log(W) = a_0 + a_1 s + a_2 s^2 + a_3 X + a_4 X^2 + a_5 T + a_6 T^2 + a_7 Z$$

The human capital variables, here, are S years of education, X−years of work experience and T years of tenure in the current firm. As of the typical functional form of human capital wage equation, wages are expressed in logarithm, and square terms of human capital variables are included also. The coefficients measure rates of increases in wages with schooling, experience and tenure respectively.

The data consist of male workers only from the random sample of the 1983 Occupational Wage Survey. In this paper we exclude female workers, whose job experiences are discontinuous, thus their OJT investments are not so considerable that their wage profiles are not much steep over experience.

Moreover, since female's OJT is not continuous and its amount is likely to be small, the productivity growth due to the technology-derived-increase of OJT to adept new technological skills would not be significant for female workers during the period of rapid economic growth accompanied by the remarkable technical improvements. Consequently, women's wages would be not quite sensitive or flexible to the economic growth or industry expansion.

Appedix Table A−1 shows means and standard deviations of the variables. These statistics are shown also by age groups, younger (Age<30), and older(Age>30) workers.

Table A−2 shows the estimated coefficients of the wage functions. Column (1) is the estimated result without including tenure. Column (2) shows the estimated coefficients including variables of tenure as well as marital status and type of work (production or non-production). Column (3) includes also coefficients of firm size dummies. Experience variable in column 2 and 3 is the prior experience instead total labor market experience.

Table A−1 and A−2 indicate that the coefficient on schooling squared term of schooling is significantly positive in both groups. As to prior experience, the younger group has positive coefficients on both X and X^2.

Table 1 summarizes the effects of key human capital variables on the growth of wages

Table 1

Growth of Wages with Education, Experience and Tenure

Equation Type		(1)	(2)	(3)
		(All Age Group)		
Education	[11]	12.29	8.43 (8.32)	7.08 (8.27)
Prior Exp	[12]	3.66	1.63 (1.81)	1.74 (1.93)
Tenure	[4]	——	6.70 (4.70)	5.91 (4.21)
		(Young Age Group)		
Education	[11]	13.90	10.11 (10.15)	9.50
(9.40)				
Prior Exp	[6]	7.07	4.30 (4.74)	4.24
(4.65)				
Tenure	[2]	——	12.32 (8.10)	11.71
(7.54)				
		(Old Age Group)		
Education	[11]	11.78	8.38 (8.14)	8.47
(8.14)				
Prior Exp	[16]	1.93	0.72 (0.77)	0.95
(0.99)				
Tenure	[6]	——	4.56 (3.89)	4.31
(3.41)				

Notes: The values in [ ] are the mean levels of the variables. The type of wage equations is refered to Tables A−2.
The values in parentheses are the estimates from the wage equations with total labor market experience instead prior experience. And the mean level of total experience is 16, 6 and 21 years for all, young and older age groups respectively.
The regression coefficients with total experience are omitted.

based on the Table A－2. The figures show the partial derivatives of log wages with respect to education, experience and tenure. Those values are calculated at the mean level of the variables.

Comparing these results for Korean workers with the empirical studies about Japanese and U. S. workers, (Table A－3, from Mincer & Highuchi (1987)) we found that, first, the mean level of schooling of Korean workers is a little less than those of U. S. and Japanese workers, whereas the distribution of schooling is more disperse among Korean workers.

Secondly, the average length of tenure is shorter among Korean workers compared to those among U. S. and Japanese workers. Presumably because current short tenure is correlated with higher rates of turnover in the labor market.[2] The Korean labor force is relatively young compared to those of both countries.

Finally, the coefficient of schooling looks more similar to that in U. S. in that both countries have positive coefficient on the squared term. However, the profitability of education indicates the returns to schooling is higher than the returns to American workers. And the coefficients of work experience and tenure are larger than those of Japanese as well as American workers.

Wages grow with experience in Korean labor market more rapidly than in Japanese labor market. As is the case of Japanese workers, when tenure is added, the total experience coefficient is reduced by large amount due to the strong effect of tenure on wage growth. This fact suggests that the amount of human capital is more accumulated within a firm as in Japan.

Considerably high growth rate of wages over tenure suggests quite steep tenure-wage profiles, relatively steeper than Japanese wage trajectories. Examining the tenure effect by age group, it is found that the tenure effect for younger group is quite high, larger than that effect in Japan and U. S.. And this effect for older workers is not so strong as that for Japanese workers, and still considerably higher than that for U. S. workers.

This finding suggests that, as a human capital interpretation, OJT in Korean firm processes much more over younger age compared to that in U. S. or Japan. And the OJT is fairly continuous over older ages, but the extent of continuity in OJT over the older span is rather short compared to that in Japanese firm. Probably, the retraining of old workers in Korean firm is less frequent and emphasized than in Japanese firm.

But the general feature of the magnitudes of coefficient is quite similar to the figures in

Japanese labor market, not to those in U. S.

Ⅲ. Productivity Effects on Wages; Industrial Evidence

Our objective here is to test the effects of productivity changes on the wage growth, that is, on the slope of wage profile, using the indexes of productivity growth at 2—or 3—digit industry level. We use here two sets of total factor productivity indexes, and another three sets of labor productivity indexes. Table A—4 shows these indexes.

Column 1 is the estimated total factor productivity (roughly 2-digit, for all industries) computed by Yeon (1980) based on the Solow's growth model for the period 1962—76. Column 2 is the estimated residuals (3-digit manufacturing industries only) for the period 1963—79 used by Park (1987). Column 3 is the annual growth rates of labor productivity in terms of value added per worker calculated by Yeon (1980). Column 4 shows the annual growth rates of gross value added per laborer (2-digit for manufacturing and 1-digit for other industries) for the period 1974—83. Column 5 is the computed labor productivity for the period of 1971—83 from the labor productivity index in the Yearbook of Labor Statistics, (YLS) 1984.

First, the productivity growth indices are included in the wage equation to find the effects of sectoral productivity growth on wages of individual workers. Next, in order to test the effects of differential sectoral productivity growth on tenure-wage slopes, we include also an interaction of productivity growth index with tenure in the wage equation. This interaction term would allow us to ascertain whether tenure-wage slopes are steeper in industries where total factor or labor productivity growth is faster.[3]

Table 2 shows the results on the estimated coefficients of differential productivity growth and interaction of productivity growth with tenure in wage equations.

The coefficients of productivity growth show all positive and significant except the index A. When the interaction with tenure is included additionally, the effect of differential productivity growth in industry on tenure-wage slopes is quite quite strong and significant in case A. In the manufacturing sector the productivity growth effect on the slope of tenure-wage profiles is negative but insignificant.

Table 2

Coefficients of Productivity Indexes and Interaction of Productivity With Tenure in the Wage Equation

	(A)	(B)	(C)	(D)	(E)
(1)					
PrG	−0.1515	1.3935	0.3409	0.4973	0.2816
	(−0.57)	(7.73)	(3.34)	(4.10)	(2.46)
(2)					
PrG	−1.5685	1.5408	0.2046	0.2289	0.3813
	(−4.22)	(5.74)	(1.46)	(1.35)	(2.34)
PrG * Ten	0.3079	−0.0317	0.0299	0.0563	−0.0260
	(5.45)	(−0.74)	(1.41)	(2.27)	(−0.86)
(3)					
PrG * Ten	0.1065	0.1537	0.0446	0.0554	0.0139
	(2.69)	(5.35)	(2.96)	(3.07)	(0.66)

* : A to E refer to the productivity indexes in order. See in Table A−4. And t-values are in parentheses. The type (3) Wage equation in Tabel A−2 is used for these results. The coefficients of other explanatory variable are omitted.

When we divide the sample by age group, Young (<30) and Old (>30) groups, we find a quite striking difference in the effect of productivity growth in industries on log wages by age group. Especially compared to the results for Japan and U. S., the difference in the effect of productivity growth by age group is quite remarkable.

Table 3 shows the regression results by age group. Column (I) uses the labor productivity index D, and Column (II) uses total factor productivity index B for manufacturing industry only.

The results in Table 3 exhibit that the effect of productivity growth is more significant among young workers than among older workers. The productivity effect on the slope of tenure-wage profiles is also stronger among young workers. Although this effect in manufacturing sector is somewhat different, the coefficient of interaction term only shows a larger effect in young group.

Table 3

Coefficients of Productivity Indexes and Interaction of Productivity With Tenure in the Wage Equation

	(Young Workers)		(Older Workers)	
	(I)	(II)	(I)	(II)
(1)				
PrG	0.7231	1.6085	0.2589	1.2460
	(4.24)	(6.91)	(1.56)	(4.71)
(2)				
PrG	0.2182	2.1989	−0.0477	1.1784
	(0.91)	(6.03)	(−0.18)	(2.60)
PrG * T	0.2425	−0.2302	0.0462	0.0104
	(2.97)	(−2.10)	(1.50)	(0.18)
(3)				
PrG * T	0.3150	0.3489	0.0245	0.1285
	(4.75)	(4.36)	(1.29)	(4.00)

IV. Duality Hypothesis on the Relation Between Wage Growth and Turnover Behavior

Human capital theory suggests that the steeper tenure-wage profiles are directly linked to human capital investment in worker's skills on the job, and at the same time such investments in human capital are also related to low turnover rates. A proposition on this linkage between wage growth and turnover pattern is referred to as the duality hypothesis.

The human capital duality hypothesis states that longer investments in workers on the job result in steeper tenure-wage profiles and, given a degree of specificity per unit human capital, turnover is smaller the steeper the profile.

(i) : Theoretical Issue on Turnover Behaviour

According to specific human capital theory, the more specific human capital a worker accumulate in the firm, the longer the worker is likely to stay with the firm. Individual differences in mobility behaviour are mainly produced by differential firm-specific human capital formations among workers, which are proved to be positively related with job tenure in the firm.

Mincer & Jovanovic (1981) analyze the relationships between job tenure, wages and labor mobility. They formulate and estimate a separation equation (tenure-turnover profile), S(T) which shows a relationship between the probability of separating from a job and the current job tenure. For an individual, it is a profile of "propensity to move" conditional on tenure. Their estimation prove that the tenure profiles (within same experience groups) are steeply declining and decelerating, which exhibits convex feature of turnover behavior.

$$\frac{ds}{dx} = \frac{\partial S}{\partial T} - \frac{dT}{dX} + \frac{\partial S}{\partial X}$$

A decline in turnover should be observed as age (or experience) advances, since $dS/dX<0$. The reason is that $\partial S/\partial T<$as the specific human capital theory assent, and the 'pure aging' effect given T would be negative, that is $\partial s/\partial x<0$. And in normal case, $dT/dX>0$, it would be zero, only if turnover of a worker is instantaneous inter-jobs or firms. As a summary, specific human capital theory asserts that the declining trend of turnover rates over work experience, $dS/dx<0$ is mainly due to the negative tenure effect on turnover, $\partial S/\partial T<0$.

We may argue that the negative tenure effect on turnover is rather due to the unobservable heterogeneity among workers, without resorting to the specific training theory. The heterogeneity can occur among workers who are different in ability or in propensity to move across firms, or even in propensity to invest on specific training on the job. The observed negative relation between turnover and tenure is explained by the existance of heterogeneity in turnover propensities among workers. The greater the heterogeneity the steeper the observed separation profile. Thus, even in the case that there is no specific human capital, i. e., the pure tenure effect is zero, $\partial S/\partial T=0$, we could observe a downward declining turnover profile due to the pure heterogeneity effect on the mobility. Then from the separation equation, we see the decline of turnover with experience will be only due to pure aging effect, $\partial S/\partial X$. It implies that the experience effect on separation would be same independent of the length of tenure. However, this is not the case in the empirical studies. (Mincer & Jovanovic 1981).[4]

(ii): Productivity Growth Effect on Turnover Behavior

We are now interested in the effects of productivity growth on mobility behavior, and compare with the results on the relation between wage growth and productivity growth. In the growing economy, rapid technical improvements take place. Human capital accumulation of workers would differ across industrial sectors in which the rates of technological progress differ. Especially, in the rapidly developing countries where unbalanced growth of economy has been pursued as an economic policy of rapid industrialization, wage differentials are shown quite large across industries reflecting differential accumulation of human capital in industries due to rapid technical changes.

We are concerned with the productivity effect on turnover rates in this situation where considrable differential technical progress has been made across industrial sectors.

Our data do not provide information on separation rates such as quits or layoffs or prior job changes. If we had direct informations on turnover behaviro, then we could estimate turnover functions which corresponds to the wage functions. However, we may have an avenue to figure out separation behaviors. Since we have individual data on years of tenure in the firm, we may regard a worker who has less than 1 year tenure as a "mover". And a worker who has more than 1 year tenure is considered as a "stayer" in the firm. However, in order to exclude newcomer in the labor market, we are concerned with workers who have more than 1 year general experience in the labor market. Then we construct a separation variable S, which has the value 1 if a worker is mover, and has 0 if he/she is stayer.[5)]

If the differential sectoral productivity growth has a positive effect on the level of wages and the slope of tenure-wage trajectories through an increase of specific human capital investments in the firm, then this productivity growth would have a negative effect on the probabilities of turnover, and thus a positive effect on the length of tenure as the specific human capital theory suggests.

We proceed to test this duality proposition by using the separation variable created by the above-mentioned procedure. The separation variable as a dependent variable is regressed on the set of explanatory variables including productivity growth as in the wage equations.[6)]

Table 4 exhibits the regression results of separation variable on a set of human capital characteristics and productivity growth; Index D. The empirical results of separation equations show several peculiar aspects: (i) Schooling and firm size do not have significant effect on the turnover behavior of workers. In a cross-section data more educated workers tend to have short work experience, especially for young workers, then such a negative correlation between schooling and experience may affect turnover behavior.

(ii) Marital status has, as expected, a significant effect, since married workers are less likely mobile than singles due to the considerations on family stability. Thus this effect is insignificant among young workers, whereas quite significant among older workers.

Table 4
Regr s ion Results of Separation Equations

	All	Young (A<30)	Older (A>30)
Intercept	0.4282	0.5297	0.4665
	(12.08)	(9.67)	(10.30)
Sch (=9)	0.0053	−0.0204	−0.0026
	(0.42)	(−0.91)	(−0.21)
Sch (=12)	−0.0052	−0.0237	−0.0032
	(−0.39)	(−0.97)	(−0.24)
Sch (=14)	−0.0019	0.0238	−0.0240
	(−0.09)	(0.69)	(−1.05)
Sch (=16)	0.0136	0.0097	−0.0196
	(0.81)	(0.31)	(−1.18)
Ex	0.0080	0.0401	−0.0067
	(5.23)	(8.53)	(−3.80)
Ex * Ex	−0.00018	−0.0021	0.00019
	(−4.32)	(−6.52)	(4.68)
Married	−0.0521	−0.0020	−0.0814
	(−4.89)	(−0.15)	(−3.54)
Type of Work	0.0000	−0.0011	−0.0032
	(0.00)	(−0.09)	(−0.37)
Size 1	0.0330	0.0318	0.0681
	(1.24)	(0.82)	(2.47)
Size 2	0.0150	0.0069	0.0501
	(0.58)	(0.18)	(1.85)
Size 3	−0.0032	−0.0157	0.0541
	(−0.12)	(−0.40)	(1.94)
Size 4	0.0045	0.0151	0.0399
	(0.18)	(0.41)	(1.53)
PrG (Index D)	−0.1442	−0.0379	−0.2365
	(−1.59)	(−0.27)	(−2.59)
R^2	0.3512	0.5737	0.2940
N	6,726	2,979	3,747

(iii) prior experience is positively related with the possibility of separation. It implies that a worker who has more prior experience is more likely to have higher frequencies of separation. However, the result will differ if the sample is divided by age group. The prior experience is also negatively related to the possiblility of separation for older workers. It might be mainly aging effect; older workers become less mobile, because, as humna capital theory suggests, the opportunity costs (foregone earnings) incurred by separation from the job is bigger as they get older.

Table 5 shows the estimated results about the productivity effect on turnover of workers. It shows that productivity growth has negatively affected on turnover behavior.

Table 5
Coefficients of Productivity Growth in Separation Equation
By Age Group

	(A)	(B)	(C)	(D)	(E)
PrG	−0.1859	−0.0391	−0.0921	−0.1442	−0.0066
	(−0.93)	(−0.27)	(−1.20)	(−1.59)	(−0.11)

	(Young Workers)		(Older Workers)	
	(I)	(II)	(I)	(II)
PrG	−0.0379	−0.0941	−0.2365	−0.0694
	(−0.27)	(−0.45)	(−2.59)	(−0.48)

* : The coefficients of other independent variables, human capital characteristics, type of work and firm size are omitted.

The unanimously negative coefficients of productivity growth in the separation equations can, not clearly significant though, lend support the duality hypothesis with its positive coefficents in the wage equations.

Table 5 also reports the results for effects of productivity and employment growth by age groups. The empirical results by age group seems to support clearly the duality proposition. The result for all industry (columns I) shows that the negative effect of productivity growth is more significant and stronger in older workers, implying that older workers are more reluctant to separate from the firm in the industries in which the rates of productivity growth is faster. It may be consistent with the implications from human capital theory.

The result for manufacturing industry (columns Ⅱ) shows that negative productivity growth effect is not quite significant in both age groups, and the magnitudes of its coefficient are not so differenct. A little larger magnitude of productivity effect for young workers in manufacturing industries could be explained by the human capital interpretation.

The manufacturing industry in Korea has shown rapid rates of technical progress. In order to adopt the fast technical changes in the course of rapid industrialization process, the workers, particularly young workers, in this industry require more investments in the on-the-job training. Consequently more technology-specific human capital accumulated by young workers in the manufacturing sector could slow down the turnover rates of young cohorts, since workers in this industry who invest more on specific training are likely to stay in the firm.

V. Old and New Technologies and Obsolescence of Human Capital

One effect of rapid changes in technology is an increased depreciation of human as well as physical capital due to obsoescence. The pay off period of investments in human capital would be shortened. Then the less amounts of training cost are invested at a given time, but the investment on training is more likely to be repeated over the work span.

Therefore, the total volumes of training over the working life can increase in the growing economy with rapid technological progress, presumably because of the greater profitability of the up-to-date training. Since the investments do not decline much over the work span, wage profiles do not decelerate much. Furthermore, to the extent that the continuing job investments to catch up with new technology in the firm is technology-specific or firm-specific, the greater specificity of human capital on the job would accentuate the decelerating trend in tenure-wage profiles.

The evidence from the Table 1 confirms the lack of deceleration in tenure-wage profiles in Korean data, which is similar to the Japanese evidence, and contrasted with significant declines in tenure-wage slopes at older ages in the U. S.

Table A－5 shows the results on the coefficients of interaction of productivity growth in industry with tenure in wage functions in the U. S. and Japan. A Particular interest is given to these coefficients, when long-and short term productivity growth variables are included together in the wage function. When these two productivity indices are used separately, they are both positive and significant in Japan, and in the U. S. panel the short-run productivity effect is not significant.

Interestingly, when both variables are included together, the long term productivity growth effect is significantly negative effect on the slope of tenure-wage profiles in Japan, whereas short-run productivity effect is strongly positive. We may catch a distributed lag effect of technical changes from those coefficients. Such a lag effect is quite short in Japan compared to that in the U. S.

Although our data do not contain a long series of productivity growth index, we have relatively out-of-date productivity index (1962—76) and quite recent productivity data (1974—83). The separate effects of these productivity variables are shown in Table 2. Column (1) indicates a negative effect of old productivity in the wage level, and a positive effect on the slope of wage profiles, while a positive effect of new productivity on the level as well as the slope of wage profiles.

When we include both variables together, the results are seen in Table 6. The coefficients indicate that the result from the separate estimations, using each productivity index alternately, is qualitatively intact; old productivity growth effect on the wage level is negative, and new productivity effect is strongly positive in wage equations. However, the effect on the slope of tenure-wage profile is positive in both cases. The finding on the effect of old productivity growth on wages implies that old skills are generally useless, even negative effect, because of their obsolescence, but it could be still useful for workers whose tenure in the firm is quite long.

Productivity effect by age group suggest that the effect is pronounced in young workers. A strong interaction effect among young workers implies that tenure-wage profiles are much steeper for the young group compared to the older group. This finding also confirms the results in Tabel 1 on the growth of wages with tenure. Presumably this phenomenon indirectly suggests that Korean firms are likely to train young workers rather than to retrain older workers, especially firm-specific human capital investments are needed on the job. It may partially account for the finding that the turnover rates among older workers are higher than Japanese old workers so that average length of tenure of Korean workers is shorter than Japanese.

Table 6

Old-& New Productivity indexes in Wage functions
With Interaction With Tenure

	(All)	(Young)	(Old)
PrG1 (1962−76)	−0.1889	−0.4030	−0.3206
	(−0.71)	(−1.09)	(−0.88)
PrG2 (1974−83)	0.5546	0.8468	0.2667
	(4.49)	(4.86)	(1.59)
PrG1	−1.4989	−1.8867	−2.5543
	(−4.04)	(−3.62)	(−4.36)
PrG1 * Ten	0.2781	0.6386	0.3396
	(4.89)	(3.62)	(4.77)
PrG2	0.2801	0.3719	−0.1433
	(1.63)	(1.52)	(−0.54)
PrG2 * Ten	0.0465	0.1917	0.0471
	(1.83)	(2.20)	(1.50)

Old- & New Productivity Indexes in Separation Functions

	(All)	(Young)	(Old)
PrG1	−0.1777	−0.1601	0.1702
	(−0.89)	(−0.53)	(0.84)
PrG2	−0.1216	−0.0110	−0.2078
	(−1.31)	(−0.08)	(−2.22)

Table 6 also reports productivity growth effect on separation rates. Both old- and new technologies effect negatively on the turnover behaviors of workers. Especially, the effect of the productivity growth based on new technology is significantly negative on turnover rates among old workers.

Ⅵ. Conclusion

This paper explores a relatively new branch of human capital theory; the relation between technological progress and the accumulation of human capital. It is mainly concerned with the effect of technological progress in the economy on the earnings level and the growth of earnings. Also, this paper deals with the technological progress effect on the turnover behavior of workers, as the human capital duality hypothesis suggests.

Our comparable regression results to U. S. and Japanese studies show that investments on OJT in Korean labor market are concentrated more over younger ages compared to the results in U. S. and Japan. The investments in OJT are fairly continuous in older ages, but the length of OJT is shorter than that in Japanese firms.

The estimated results on the coefficients of differential productivity growth and the interaction of productivity growth with tenure are positive and quite significant.

The productivity effects by age group show that the productivity growth effect on wages is more significant among young workers. Its effect on the slope of wage profiles is also stronger among young groups.

The human capital duality hypothesis, which links wage growth and turnover behaviour, suggests that continuous investments in the on-the-job training results in steeper tenure-wage profiles, and turnover rates decrease the steeper the profiles. Hence, we also perform the test of productivity growth effect on turnover behaviour.

Since our data do not provide information on separation rates, we can construct a separation variable which dichotomize workers into "mover" and "stayer". We estimate the separation equation in which the separation variable is the dependent variable. The empirical results show that productivity growth has a negative correlation with turnover behaviour. But the coefficient is not as statistically significant as it is in wage equations. However, the negative direction of the coefficient is obviously clear. The significance is much weaker in the manufacturing sector. The result lends support to the duality hypothesis. The estimates by age group indicates that the negative effect of productivity growth is more significant and stronger in older workers.

One effect of rapid changes in technology is an increased depreciation of human capital. Because it is due to obsolescence, we check for the possibility of obsolescence in the Korean labor market. We include both old and new productivity growth indexes together in wage and separation equations. Our results indicate that the old productivity growth effect on the wage level is negative and the new productivity effect is positive. The effect on the slope of tenure-wage profile is positive in both cases. The effect on separation behaviour is negative in both productivity indexes. Also, the effect of new technology on turnover rates among older workers is significantly negative.

Footnotes

1. Tan (1987) refers this type of human capital as technology-specific human capital.
2. A recent study by Bai (1985) pointed out that Korean workers display a high turnover rate in general, and the rate is highest in the manufacturing sector. (p. 115) Monthly average separation rates in all industry (1970−83) are ranged between 3.7−5.1%, (4.4−6.3% in manufacturing sector).
3. It is found that using tenure instead of experience as interaction with productivity variable brings about more appropriate result, especially looking at the effect of technology specific human capital. Higuchi (1986), Mincer & Higuchi (1987) use interaction of productivity with tenure rather than with experience.
4. Table 1.2 from Mincer & Jovanovic's paper (p. 25) shows that mobility declines significantly with tenure within each experience cohort ranges.
5. As an indirect way, we may include directly the productivity indices in the tenure equation to test the duality relation, for the length of tenure can be regarded as a proxy which has an inverse relation with turnover probabilities. But in this case, it may be difficult to interpret that the coefficient reflects properly the relationship between productivity growth and job tenure. Because in a rapidly growing economy, the cross-section data would have a tendency that tenure would be shorter for those workers who are young and more educated, and the effect of productivity growth will be stronger for those workers.
   In fact, the average length of tenure in our data is relatively short. The coefficients of productivity indices which are included in the tenure equation turned out to be negative except the case of Productivity Index D.
6. Since the separation variable is a dichotomous (0, 1) discrete variable, it may be better to use probit estimation. Here we rely on the usual OLS procedure because of costs. However, the OLS results are not qualitatively different from probit estimates.

Appendix

Table A−1

Summary Descriptive Statistics of Key Variables

	All	Young (Age<30)	Older (Age>30)
Schooling	11.18 (2.94)	11.19 (2.61)	11.15 (3.20)
Experience	11.54 (9.06)	6.42 (3.77)	15.81 (8.21)
Tenure	4.25 (4.20)	2.12 (2.05)	5.94 (4.68)
Age	32.97 (8.53)	25.73 (3.44)	38.95 (6.67)
Work Hours	197.4 (24.3)	198.5 (23.0)	196.5 (25.3)
Overtime	37.8 (38.7)	38.9 (36.7)	37.0 (40.4)
Base Wage	247,627 (166,410)	184,497 (90,499)	298,851 (194,113)
Bonus	669,628 (781,454)	420,379 (455,176)	870,176 (920,602)
Monthly Wage	350,291 (214,658)	258,916 (118,360)	424,482 (244,576)
Hourly Wage	1,577 (1,124)	1,141 (607)	1,930 (1,308)
N	6,898	2,738	4,160

Standard deviations are in parentheses.

Table A-2

Regressions of Log Wage Equations

Explanatory Variables	Dependent Variable: Log (Hourly Wage) (1)	(2)	(3)
Intercept	6.3709	6.9884	6.7670
Schooling	−0.1477	−0.1623	−0.1582
	(−12.39)	(−14.75)	(−14.57)
Sch * Sch	0.0123	0.0112	0.0109
	(23.80)	(23.27)	(22.93)
Exp	0.0782*	0.0341	0.0344
	(40.46)	(16.69)	(17.08)
Exp * Exp	−0.0013*	−0.00074	−0.00071
	(−27.07)	(−13.64)	(−13.27)
Tenure		0.0764	0.0707
		(26.87)	(24.86)
Ten * Ten		−0.0017	−0.0015
		(−10.91)	(−9.58)
Married (=1)		0.1435	0.1382
		(10.04)	(9.80)
Type of Work		0.2390	0.2621
(Non-production=1)		(21.72)	(23.85)
Firm Size (30<N<100)			0.1175
			(3.34)
Firm Size (100<N<300)			0.1736
			(5.06)
Firm Size (300<N<500)			0.2119
			(5.99)
Firm Size (N>500)			0.2809
			(8.51)
R^2	0.5198	0.5934	0.6047
N	6,898		
Mean of Log(Wage)	7.1727		

* : Total labor market experience; Others are prior experience.

Table A-2 (Continued)

Regressions of Log Wage Equations
By Age Group

Explanatory Variables	Dependent Variable: Log (Hourly Wage) (Young Workers) (1)	(2)	(3)	(Older Workers) (1)	(2)	(3)
Intercept	5.8599	6.2781	6.1679	6.6944	7.2879	6.9700
Schooling	−0.0678	−0.0665	−0.0665	−0.1613	−0.1915	−0.1846
	(3.29)	(3.90)	(3.93)	(10.65)	(13.18)	(12.91)
Sch * Sch	0.0094	0.0076	0.0073	0.0127	0.0125	0.0122
	(10.64)	(10.25)	(9.94)	(19.26)	(19.78)	(19.63)
Exp	0.0592*	0.0156	0.0170	0.0592*	0.0267	0.0278
	(7.49)	(2.72)	(2.98)	(13.33)	(8.31)	(8.76)
Exp * Exp	0.00072*	0.0023	0.0021	−0.00095*	−0.00061	−0.00057
	(1.46)	(5.69)	(5.33)	(10.76)	(8.05)	(7.66)
Tenure		0.1451	0.1379		0.0550	0.0506
		(19.17)	(18.24)		(14.28)	(13.23)
Ten * Ten		−0.0055	−0.0052		−0.00079	−0.00063
		(5.46)	(5.23)		(4.20)	(3.35)
Married		0.0485	0.0521		0.1335	0.1309
		(3.03)	(3.29)		(3.19)	(3.18)
Type of Work		0.2414	0.2621		0.2298	0.2531
		(16.31)	(17.49)		(14.69)	(16.26)
Firm Size D1			0.0961			0.1288
			(2.02)			(2.61)
Firm Size D2			0.1192			0.2165
			(2.57)			(4.48)
Firm Size D3			0.1384			0.2713
			(2.90)			(5.43)
Firm Size D4			0.2081			0.3295
			(4.66)			(7.08)
R^2	0.4393	0.5549	0.5634	0.4205	0.5212	0.5374
N	2,738			4.160		
Mean of Log (W)	6.8660			7.3746		

* Total labor market experience. Absolute t-values are in parentheses.

Table A−3

Growth of Wages with Education, Experience and Tenure

		Japan	U. S.	U. S.*
		(All Age Group)		
Schooling	[12]	17.05%	6.45%	6.94%
Experience	[17]	.65	.95	.63
Tenure	[9]	4.19	1.22	1.01
		(Young Age Group)		
Schooling	[12]	15.63	5.78	6.27
Experience	[6]	2.25	1.94	1.91
Tenure	[3]	3.72	3.91	3.18
		(Old Age Group)		
Schooling	[12]	17.70	6.48	6.94
Experience	[23]	0.66	0.50	0.32
Tenure	[12]	4.07	1.13	0.91

Source: Mincer & Higuchi (1987).
The values in [ ] are the mean levels (years) of independent variables.
The independent varialbles of wage equations are education, total work experience, tenure at the current firm, dummy for a job changer, dummy for a married person. (*) includes dummy for a union member as a regressor.

Table A-4

Annual Growth Rates of Productivity Indexes

Industrial Classification	(A)	(B)	(C)	(D)	(E)
200	0.002	—	0.029	0.2011	0.0115
311	0.016	0.0474	0.055	0.1476	0.0938
312	0.016	0.0474	0.055	0.1476	0.0632
313	—	0.0611	—	—	0.0585
321	0.016	0.0451	0.078	0.2091	0.0708
322	0.016	0.0612	0.078	0.2091	0.0684
323	0.013	0.0792	0.029	0.2091	0.1282
324	—	0.0612	—	0.2091	0.1245
331	0.009	0.0235	0.037	0.3391	0.0060
332	0.009	0.0867	0.037	0.3391	0.1108
341	0.034	0.0006	0.073	0.2092	0.0782
342	0.050	0.0449	0.082	0.2092	0.0692
351	0.048	−0.0140	0.125	0.2111	0.0755
352	0.048	0.0940	0.125	0.2111	0.0935
353	—	0.0702	—	0.2111	0.0078
354	0.033	0.0702	0.133	0.2111	0.0825
355	0.044	0.0419	0.067	0.2111	0.0308
356	—	0.0964	—	0.2111	0.0253
361	0.030	0.0164	0.093	0.1755	0.0425
362	0.030	−0.0836	0.093	0.1755	0.0444
369	0.030	0.0229	0.093	0.1755	0.0618
371	0.049	0.0161	0.134	0.1761	0.0885
372	0.049	0.0408	0.134	0.1761	0.1318
381	0.055	0.0470	0.107	0.2238	0.1137
382	0.043	0.0502	0.106	0.2238	0.0797
383	0.029	0.0330	0.092	0.2238	0.1216
384	0.019	0.0903	0.108	0.2238	0.0725
385	0.050	0.0322	0.086	0.2238	0.0468
390	0.050	0.0322	0.086	—	0.0884
400	0.052	—	0.164	0.3031	0.0843
500	0.024	—	0.058	0.2138	—
600	0.039	—	0.070	0.1663	—
700	0.048	—	0.186	0.1776	—
800	0.072	—	0.204	0.2901	—
900	0.010	—	0.039	0.2779	—

(A): Total Factor Productivity index (1962–1976) calculated by H. C. Yeon in *Human Resources and Social Development in Korea*, C. K. Park ed., KDI, 1980.

(B): Total factor productivity calculated as Residuals (1963–1979) reproduced from the unpublished paper by Park (1987).

(C): Labor Pruductivity calculated by Yeon.

(D): Gross Value Added per capita (1974–1983) from the *Yearbook of Economic Statistics*, Economic Planning Board, 1984.

(E): Labor productivity calculated from the Labor Productivity Indexes (1971–1983) in *Yearbook of Labor Statistics*, Ministry of Labor, 1984.

*) The Standard Industrial Classification:

200; Mining

311; Food, 312; Beverage, 313; Tobacco

321; Textiles, 322; Waering Apparel, 323; Leather, 324; Footwear

331; Wood & Cork, 332; Furniture

341; Paper, 342; Printing

351; Industrial Chemicals, 352; Other Chemicals, 353; Petroleum & Coal, 354; Other Petroleum, 355; Rubber, 356; Other Plastics

361; Pottery, 362; Glass, 369; Other non-metallic Mineral Products

371; Iron & Steel, 372; Non-Ferrous Metal

381; Fabricated Metal, 382; Machinery, 383; Electrical Machinery, 384; Transport Equipment,

385; Scientific Equipment, 390; Other Manufacturing

400; Electricity & Gas

500; Construction

600; Wholesale & Retail

700; Transportation & Storage

800; Finance & Insurances

900; Other Services

Table A-5

Coefficients of Interaction of Productivity Growth
In Industry With Tenure in Wage Functions

	U. S.			Japan		
All (18-60)						
PG (60-79)	.0139	—	.008	.009	—	-.010
	(4.3)		(1.1)	(6.7)		(2.0)
PG (70-79)	—	.006	.010	—	.013	.024
		(1.5)	(1.1)		(7.5)	(3.9)
Young Group (18-30)						
PG (60-79)	.040	—	.093	.016	—	-.052
	(2.7)		(3.0)	(2.5)		(2.2)
PG (70-79)	—	-.003	-.083	—	.027	.088
		(.2)	(2.0)		(3.2)	(3.1)
Old Group (31-60)						
PG (60-79)	.015	—	.001	.009	—	.001
	(3.8)		(.2)	(6.3)		(1.4)
PG (70-79)	—	.005	.023	—	.012	.021
		(1.1)	(2.6)		(6.9)	(3.3)

Source: Mincer & Higuchi (1987).

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